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ABSTRACT

It is essential in communicative situations for teachers and students to have comparable percepts. A paucity of information is available on the percepts held by children regarding quantities and intervals of distance, height, weight, time, temperature and volume or on improvement (if any) that occurs as children mature. Teachers cannot be effective in the teaching-learning process if their own and their pupils' percepts in these areas are unclear, inaccurate, or invalid. To determine the accuracy of school children's (grades 4-12) percepts of intervals and quantities using both English and metric units of measure, this study involved nearly 50 teachers and some 2300 children in field experiences estimating distance, air temperature, weight, height and acreage. Extensive data supported the hypotheses that school children have inaccurate or invalid percepts of intervals and quantities of distance, weight, height, area and temperature and that percepts expressed in English units are more accurate than those expressed in metric units. Results also indicated that: children do estimate some things, such as distance, more accurately than other things, such as weight; some differences because of sex and urban versus rural home location exist; and high school students perform better than younger children. Evidence supported the notion that percepts can be clarified and reinforced through direct, first-hand experience. (NEC)

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RESEARCH REPORT

DISTANCE, WEIGHT, HEIGHT, AREA AND TEMPERATURE PERCEPTS OF SCHOOL CHILDREN

by

Malcolm D. Swan & Orville E. Jones

1973

DISTANCE, WEIGHT, HEIGHT, AREA AND TEMPERATURE PERCEPTS OF SCHOOL CHILDREN

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Educational objectives, particularly in science and mathematics include the development of our understanding of the world in which we live. Hence, attention to the development of percepts or mental images of intervals and quantities of distance, weight, height, area, and temperature seems in order.[1] If teaching activities using such intervals and quantities are to achieve results, students must be provided with background reference intervals and quantities they can fully understand and visualize.

Comprehension of distances between and across cities and continents, for examples, appear to have meaning only to the degree that learners can visualize shorter intervals of distance such as "one hundred feet," "twenty-five meters," etc. Without some experiential basis for understanding these units of measure, comprehension and retention are likely to be minimal.

A similar condition exists in regard to other quantitative measures such as volume, weight, height, time, etc. . Children, and some adults, with few first-hand experiences on which to base a "gallon concept," find reference to the per gallon cost of milk difficult to understand. Learning abstractly that three thousand or more gallons of oil may be required to heat a home is even more incomprehensible, Reading about the heights of various trees is probably of little consequence to a child who is weak in height percepts. Telling a child who has vague time percepts to "wait a minute" or "come back in a half-hour" results only in confusion. Memorizing the number of square feet in an acre may be a futile exercise to the learner who lacks a clear mental image of what an acre looks like, or lacks understanding of what the term "acre" signifies.[2]

In many science or mathematics classes, discussion frequently centers about such quantitative and interval concepts. Some examples might include a distance of one hundred or X-number of feet; or a weight of five or X-number of pounds;or a height of fifteen or X-number of feet. When quantities such as these are used in a communicative situation, considerable doubt may exist concerning the degree of understanding or lack of understanding that takes place between the writer and reader, or speaker or listener. The extent to which communication occurs depends on the degree to which the users or learners of a given quantity have had similar experiences and perceptions.

In an earlier study (Science Education 55 (3), 1971) the writers found that university students preparing to teach:

a. have inaccurate or invalid percepts of intervals and quantities of distance, weight, height, acreage and temperature, using both English and metric units of measure. (In most instances, the majority of the estimates in English units were in error by more than 25 percent. Among the exceptions were the height and temperature estimates);

b. have less accurate percepts of such intervals and quantities using metric units than English units;

c. have more accurate percepts of heights and air temperature than for distances, weights and acreage;

d. seldom gave estimates that indicated that they understood the proper relationships between kilogram and pound or between the Fahrenheit and Centrigrade scales. (They more frequently gave estimates indicating the understood the relationship between feet and meters, however.);

Purpose of Study

This study was undertaken to learn the accuracy of the percepts of intervals and quantities of school children using both English and metric units of measure and to test hypotheses like these:

a. School children (grades 4-12) have inaccurate or invalid percepts of intervals and quantities of distance, weight, height, area and temperature. As in the earlier study, the reasearchers arbitrarily judged an estimate smaller than 75% or larger than 125% of the actual interval or quantity to be inaccurate. A return of more than 50% inaccurate student responses to an item was considered as being supportive of this hypothesis.

b. School children's percepts expressed in English units are more accurate than those expressed in metric units.

c. Accuracy of children's percepts in one area such as distance or weight, etc., is not significantly different from the accuracy of their percepts in other areas.

d. Children have little understanding of the relationships or ratios between commonly used English and metric units of measure. Children's estimates varying 25% or more from the actual ratio were arbitrarily judged indicative of "little understanding" and supportive of this hypothesis.

e. The accuracy of children's percepts and estimates is independent of age or grade level, sex, or home (rural or urban).

A secondary purpose of this study was to involve a number of teachers and pupils in field experiences involving the estimation of intervals and quantities using both English and metric units.

Review of the Literature

Writers give little attention to children's percepts of intervals and quantities of distance, volume, height, weight, temperature, time, etc. Although several studies concerning children's percepts of short intervals of time have been reported, this general area appears to have attracted little attention from investigators. Much of the research has been confined to pencil and paper reporting of the relationships between quantities such as the number of square feet in an acre, quarts in a gallon, and the like. Researchers seem to have ignored children's percepts, mental images, or concepts of such intervals and quantities

Importance of percepts. Several writers discuss the need for having reasonably accurate percepts of space, weight, and quantity for day-to-day living and for understanding the data Spencer and Brydegard state:

> Quantitative phenomena occur with every type of sensory stimulation whether it be aural, visual, tactile, thermal, olfactory, gustatory, kinesthetic, or any other. And all types of stimula are utilized in adapting one's behavior with regard for one's environment. Consequently, instructional procedures must utilize multisensory aids rather than being content with concentrating on a single or even a few types.[4]

Blough and others point out the great need to develop concepts basic to an understanding of space, i.e. concept of distance, direction, length, weight, time, and motion, and that this may be thought of as development of "space readiness."[5] West and Hillcourt provide reasons for a person wanting to be able to estimate heights, distances, numbers, weights, etc. in the Scout Field Book.[6]

Russell devotes considerable attention to sensations, images, percepts, memories, and concepts, and calls them the "materials for thinking." In defining these factors he calls a percept a reorganization of a series of related

sensations from external and internal stimuli, and indicates that they in turn give rise to more generalized experiences or concepts. He says, "The parent, teacher, and child psychologist can easily understand that some of the young child's difficulties in getting along in this world may be due to incorrect percepts.[7]

Although Russell seems to have difficulty in clearly delineating his "materials for thinking," he classified percepts into nine categories including those of distance, weight, time, and quantity, and sees a relationship between these and the development of scientific concepts. Both he and Spencer find a close relationship between children's mathematical concepts and perceptions of number, space, weight, and quantity.[8] Spencer and Brydegard say:

> Size, order, and amount are characteristic of experiences with quantity. And quantity is observable in all things and all situations. From a broad point of view, mathematical experiencing consists of all behavior with regard for quantity and quantitative relationships.[9]

Schultz, Holmes, and Sauble use the "quart" concept as a way to illustrate the importance attached to percepts. They say:

> The concept of quart functions in descriptive situations that range from simple visual and manual impressions to a mental visualization which must be conjured out of a complex situation presented in either oral or written form. The concept of a quart involves impressions of its size; of size in relation to shape, to use, and to weight. The concept is developed in relation to quarts of things in relation to other standard measures such as the pint and gallon, and to such less definitive units as cupful, canfull, and other containers used in the home and school. Closely associated with the concept of of quart is a wealth of information about its use.[10]

Percepts of children. Russel refers to the work of Piaget and Inhelder and points out that:

> . . . they believe that children develop abilities in space perception in a sort of geometric order. First they develop understanding of topological space as represented in such concepts as nearness, separation, order, enclosing, and continuation. Then the they begin to perceive and understand projective space and Euclidean space, involving figures in relation to each other in projective or coordinate systems, perspective, and various geometric measures. Piaget believed that images may play an important role in such learnings and advocates the child's having many opportunities for manipulating concrete objects.[11]

Russell indicates that little is known about children's knowledge of weights and measures and uses the work of Wilson and Cassell as an illustration of the way this problem has usually been approached. They questioned over 6,000 children in grades two through ten about quantitative relationships. Of particular pertinence to this study is the third section of their questionnaire in which they asked children to make estimates such as the height of a dining room table and the distance between the rails of a railroad. The percentage of reasonable answers was low--only five percent correctly estimating the height of a dining room table.[12]

Spencer and Brydegard take the position that estimates of quantity are difficult for either children or adults and point out that , " . . . the adult is frequently less capable than the child in estimating quantity." They point out that students in college who have not developed good standards of reference for estimation in size, distance or amount may be less capable than young children and quote one college girl as saying, "I never thought about how to estimate. I just learned the tables

the teachers asked us to know. After seeing the children develop standards of reference, I know how to improve my estimating of things.[13]

Nothing appears in the literature to indicate what, if anything, is known about the percepts of children relative to quantities and intervals of height, distance, weight, temperature, etc. If improvement occurs as children move through the grades; if there is a difference among and between categories of children; or if they consistently tend to over or underestimate these amounts seems to be unknown.

An exception seems to be the perception of time intervals. Several studies have been reported in which these have been included. Ruch says:

> Everyone has observed that time spent in monotonous work is overestimated at the time, while time spent in interesting work is underestimated at the time. Psychologists confirm this everyday observation. In general, time spent pleasantly, is estimated to be shorter than time spent unpleasantly, when it is estimated at the time.[14]

According to Russell, the section of the research summary by Gilliland and others on "learning in time perception" has broader implications. Like spatial perception, temporal perception is complex, and for a child often difficult. Later reports on children's concepts suggest that understanding of time units is slow in developing.[15]

Perceptual training in schools. Gibson points out that the psychological literature of the past seventy years contains a vast amount of evidence that perceptual judgments can be improved. Such skills as the following have shown definite improvement through practice: feveal and peripheral acuity; judgments in recognizing letters or aircraft; judgments of visual space involving area, angle, depth and distance; and auditory discrimination of pitch.[16]

A similar position is taken by Russell as he points out that many opportunities to explore and manipulate concrete materials help the young child's development.[17] He suggests that the home and school give the child many opportunities in a free and permissive environment to explore, manipulate, and play with toys, blocks, tools and other equipment. Opportunities for city children to visit the country and farm, and for farm children to visit the city, are only one example of possible ways to building accurate percepts and memories, he states[18]

There are many school situations available to the teacher who is looking for them and knows how to capitalize upon them according to Sueltz, Boynton, and Sauble. As an example,they use a "Valentine Box" and the various estimates and measurements that might be involved in its construction.[19]

Spencer and Brydegard provide several ways to improve percepts of shape, weight, position, time, temperature, space, etc. in which a great deal of estimating followed by measurement is done. In one case they used a school bus for the subject and also asked a college class to write their estimates of its length. When their estimates were compared to the children's it was decided that comparisons between adults and children should not be made. Chronological age and ability to achieve good results in estimates were not closely related.[20]

Swan deals with the specific distance interval of 100 feet and ways of developing this interval percept. He suggests that each student estimate this distance, and follow this with successive measurements--each with a more refined instrument. He points out that this exercise has applica ion for heights, weights and other quantities.[21]

Outdoor Education literature contains frequent reference to ways in which concepts of distance, area, and height intervals may be improved. Hammerman and Hammerman point to the desirability of providing each child with an "acre concept."[22] Hug and Wilson devote nearly a chapter to measurement and percepts of height, distance and time. They offer activities to develop these percepts.[23] Similar activities can be found in the curciculum guides of many school districts. In Operation New York, for instance, reference is made to estimating the depth of a road cut, height of a hill, slope, temperature on a warm day, depth of stream cut, height of bridges above water level, and sizes of buildings.[24]

Summary and Need for Research. References to children's percepts of quantities and intervals of distance, height, weight, temperature, volume, and time are sparse in the literature. That which is available deals mostly with the need for children to have reasonably accurate percepts and with descriptions of a few activities whereby by they might be improved. Little information is available, however, about the percepts actually held by children. Hence, research about the percepts actually held by children, improvement (if any) that takes place as they grow older, or factors that might be involved in their development seems necessary if programs designed to improve them are to rest on firm foundation.

Procedure

Cooperating teachers and pupils.

A number of elementary and high school teachers who had previously had contact with the writers and knew of their interest in this area were contacted by mail (see Figure 1.) and asked to assist in this study.

Directions (see Figure 2) and sufficient pupil answer cards (see Figure 3.) were sent to each teacher agreeing to participate. Nearly fifty teachers involved some 2300 children in the study.

Readers are urged to examine Figures 2 and 3 carefully as they describe what each teacher asked his/her pupils to do:

a. To estimate, using feet and meters two distance intervals, one 15 to 25 feet in length, and the other 150 to 250 feet in length;

b. To estimate the air temperature outdoors (using Fahreinheit and Centigrade) at the time;

c. To estimate, using pounds and kilograms, the weight of a wood block and a stone (or something similar) the first weighing about 12 pounds and the second about 17 pounds;

d. To estimate, using feet and meters, two heights, one of about sixty feet (perhaps a tree) and the other a shorter interval such as a flagpole;

e. To estimate the acreage of a rectangular area marked off using stakes or natural boundaries--the plot to be about 1/4 acre in size.

Each participating teacher was asked to provide the actual measurement of each item included in the stud on an answer card. In addition, each pupil was asked to provide data about himself such as age, sex, place at which lived, etc.

Lorado Taft Field Campus
Northern Illinois University
Oregon, Illinois, 61061
October 14, 1971

Mr. John Jones
Teacher
High School
Everyplace, Illinois

Dear Sir:

Dr. Orville Jones and I have recently completed a study relating to the understanding and usability of distance, weight, height, area and temperature percepts of university students.

We want to extend this study to include elementary and high school students. Thus, the purpose of this letter is to request your assistance and participation in this project.

Your participation with your pupils in this study will require the use of your school grounds and about thirty minutes of class time. Enclosed are three kinds of information: (1) a set of directions for the teacher's use; (2) a copy of the Estimate of Intervals and Quantities Answer Card; and (3) a postal card for you to return as soon as you have decided whether or not you can assist us.

We recognize that a variety of factors may deter many teachers from involving their pupils in this kind of activity; however, if it is possible for you to do this with one or more of your classes, your participation will be greatly appreciated.

If you cannot participate, we will appreciate you passing this request and the materials to another teacher who might be interested.

Sincerely

Malcolm D. Swan, Associate Professor
Department of Outdoor Teacher Education

Figure 1. Letter Soliciting Assistance from Teachers

DIRECTIONS FOR TEACHERS PARTICIPATING IN THE STUDY OF
THE DISTANCE, WEIGHT, HEIGHT, AREA AND
TEMPERATURE PERCEPTS OF CHILDREN

I. PREPARATION

A. Materials needed -- You will need to obtain or have available these materials (or intervals):

1. One answer card for each child (See Sample). Duplicate these on 3 x 5 or 4 x 6 cards, or if you prefer, contact either Dr. Jones or Dr. Swan at Taft Campus for a supply.

2. A distance interval of between 150 and 250 feet (perhaps the interval between two buildings, a building and a tree, etc.).

3. A distance interval of between 15 & 25 feet. Perhaps along a classroom wall, the width of a building or entrance way, etc.

4. A thermometer --

5. A wood block (or some other object with a density about that of wood) that weighs between 10 and 15 pounds.

6. A rock or stone (or some other object with a density about that of a rock) that weighs between 15 & 20 pounds.

7. A height interval of about sixty feet (between 50 & 70 feet) such as a tall tree, a three story building, chimney, etc.

8. A smaller height interval (between 25 & 35 feet) such as a flag pole, two story building, etc.

9. A rectangular area of about one-fourth acre -- marked off by using stakes or natural boundaries such as roads, sidewalks or a combination of these.

B. Preparing the children

1. Inform the children or students that they will be helping in a research study in which we are trying to find out how well children estimate various quantities and how well they understand various measurement terms such as <u>feet</u>, <u>meters</u>, <u>pounds</u>, <u>kilograms</u>, etc. <u>Provide no explanation of these terms, their ratios, or meansings at this time</u>.

2. Caution the children not to share estimates with other classmates or t show or copy answers.

3. Make sure that each child has an ANSWER CARD and a pencil, and before leaving the classroom have each of them provide the information that is requested in the upper corner of the card.

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Figure 2. DIRECTIONS SUPPLIED TO TEACHERS PARTICIPATING IN THE STUDY

II. CONDUCTING THE EXERCISE

1. (Answer Card No. 1) Position the youngsters to one side, but where they have an unobstructed view, of the longest distance interval. Tell them to indicate on their cards their estimate of this DISTANCE INTERVAL in FEET and in METERS.

2. (Answer Card No. 2) Repeat No. 1 above, but using the shorter distance interval.

3. (Answer Card No. 3) Ask the children to indicate on their answer cards what they perceive the air temperature to be -- First in Fahrenheit degrees, then in Centigrade or Celsius degrees.

4. (Answer Card No. 4) Have each child lift or "heft" the wood block or the other object that you have designated as "Weight No. 1"; and indicate on the answer card what he estimates the weight to be in POUNDS, and then in KILOGRAMS. (Do not give any help in regard to clues)

5. (Answer Card No. 5) Repeat No. 4 above, but using the Rock or heavier weight.

6. (Answer Card No. 6) Position the children about fifty feet from the object you have selected for the 1st height estimate (the highest object) and ask them to enter their estimate in FEET and then in METERS in the appropriate spaces on the answer card.

7. (Answer Card No. 7) Repeat No. 6 above, but using the second or shorter height interval.

8. Position the children along one boundary of the rectangular area that you have marked off. Ask them to indicate on their answer cards what they believe to be "The number of acres or the fraction of one acre contained in the area." (No. 8 on Answer Card)

9. (Answer Card No. 9) Have each child provide two words (adjectives) that he thinks best describe the WEATHER at this time, and write them on his card.

10. (Answer Card No. 10) Position the children at the front entrance of the school building and facing away from the building. Have each provide two words (adjectives) that he thinks best describe the view he sees in front and in the distance.

11. Have the children put their pencils away and permit no changes on the answer cards. Go back over each of the intervals and quantities you wish -- discussing, measuring, etc. Follow-up as you wish to make this a learning experience.

12. COLLECT THE ANSWER CARDS

Figure 2. Continued

RETURN OF ANSWER CARDS FOR ANALYSIS

1. Mark one ANSWER CARD MASTER

   Indicate on this card the correct or MEASURED intervals or quantities using a Tape, thermometer, scales, etc.

   Since the height intervals may present some problem, give as accurate a measurement as possible. Perhaps the principal or custodian can help in this regard.

   If you wish you may provide the dimensions of the rectangular plot. There are 43,560 square feet in one acre.

2. If you would like these ANSWER CARDS returned to you once we have completed our tabulations or if you would like a copy of the results of the study, indicate this on your master card.

3. Indicate on the Master card your name, school, grade level of the children who participated, and city.

4. Mail the ANSWER CARDS and the Master to:

   Dr. Orville Jones
   Taft Campus - Box 299
   Oregon Illinois 61061

5. The cards must be mailed as FIRST CLASS materials. If you wish, we will reimburse you for postage.

Figure 2. Continued

ANSWER CARD

ESTIMATES OF INTERVALS & QUANTITIES

Student's Name_____

Age:_____Year in School?_____

Sex:_____Time of Day:_____

Where do you live? City?_____
Suburb:_____Small Town?_____
Farm:_____

1. Distance interval No. 1:
   ____ Feet ____Meters
2. Distance Interval No. 2:
   ____ Feet ____Meters
3. Air temperature outdoors: F°_____ C°_____
4. Weight of Object No. 1: Pounds_____Kilograms:_____
5. Weight of Object No. 2 Pounds_____Kilograms:_____
6. Height of First Object: Feet_____ Meters:_____
7. Height of Second Object: Feet_____ Meters:_____
8. Acres in Plot:_____
9. Two adjectives best describing weather: _____,_____
10. Two adjectives best describing view:_____,_____

Figure 3. Answer Card Used for Study on Intervals and Quantities.

The children's estimates were coded and keypunched for computer analysis, using SPSS Crosstabs.

Using this form of analysis, tables were developed indicating the number and percentage of pupils in each age, sex and home category providing a "reasonable" estimate (within 25% of the actual interval or quantity reported by the teacher, except in the case of temperature in which an error of less then five degrees F. and three degrees C. was arbitrarily accepted as being reasonable) for each exercise.

Chi-square was applied to learn the significance of the apparent differences in the accuracy of the estimates of different groups of children or differences in the accuracy of the estimates for the several exercises (height, distance, area, etc.).

Results--Distance Intervals

Usable responses were received from 2310 children. In each case, the percent or amount of error for each of their estimates was computed. The percent of the children in each age (grades 4-6 and 7-12), sex, and home (urban and rural) category providing a reasonable estimate for the two distance intervals is provided in Table I. The percentage providing a reasonable feet to meters ratio in their estimates is also provided in Table I. Notice that a student might provide an accurat feet to meter ratio, but estimate the interval or quantity very inaccurately.

Many children, both elementary and high school, did not even attempt estimates using metric units--providing additional support for contentions that metric units and the metric system are, at best,poorly understood by school age children.

These general conclusions resulted from the analysis of the distance estimates:

a. Nearly all categories of children gave more accurate estimates in feet than in meters; about one-third giving reasonable estimates in feet as compared to one-fifth giving reasonable estimates in meters.

b. Generally, the students were more accurate on the shorter distance intervals than on the longer ones. About 40 percent of the shorter interval estimates in feet were accurate as compared to 25 percent on the longer interval.

c. Boys generally gave more accurate estimates in feet than girls. There was no difference by sex in the case of the estimates in meters.

d. Urban students gave accurate estimates more frequently than rural students. Rural students tended to over estimate more frequently than urban students.

TABLE I

PERCENTAGE OF PUPILS ESTIMATING DISTANCE INTERVALS "CORRECTLY"

Group or Cagegory		Longer Distance			Shorter Distance		
	Group	Feet	Meters	Ratio Feet-Meters	Feet	Meters	Ratio Feet-Meters
1. ALL	2306	26	17	30	42	26	30
2. Elementary	780	12	15	10	36	14	13
3. High School	1449	33	20	39	45	31	39
4. Rural	948	22	16	24	43	20	25
5. Urban	1358	29	18	35	41	29	34
6. Boys	1255	31	20	26	46	27	33
7. Girls	1051	20	16	26	37	25	26
8. Rural Boys	473	26	17	26	49	20	28
9. Rural Girls	475	18	16	22	38	20	21
10. Urban Boys	782	34	21	26	44	30	36
11. Urban Girls	576	23	14	29	31	29	31
12. High School Boys	879	36	21	41	47	32	41
13. Elementary Boys	366	15	16	11	42	13	13
14. High School Girls	550	27	18	36	41	32	34
15. Elementary Girls	414	9	14	9	30	14	12
16. Rural High School	507	28	15	36	50	24	33
17. Rural Elementary	419	13	18	9	35	15	14
18. Urban High Sch.	922	35	23	42	44	35	43
19. Urban Elementary	361	11	10	10	37	12	11
20. Rural High Sch. Boys	258	28	16	38	56	26	38
21. Urban High Sch. Boys	621	39	23	42	44	35	43
22. Rural Elem. Boys	211	17	18	11	40	14	16
23. Urban Elem. Boy	155	14	13	10	45	12	10
24. Rural HS Girls	249	23	14	33	43	23	27
25. Urban HS Girls	301	31	21	38	39	39	40
26. Rural Elem. Girls	208	9	19	7	30	16	11
27. Urban Elementary Girls	206	9	8	11	31	12	13

e. High school students gave correct estimates more frequently than elementary students (about 1/3 as compared to 1/10 using both feet and meters as units.

f. Generally urban high school boys were "best" and urban elementary girls were "poorest" in estimating distances.

g. Nearly one-half of the students gave no estimate of the distance interval in metric units.

h. Somewhat less than one-third of the students gave a reasonable feet to meter ratio in their estimates. Boys were accurate more frequently than girls.

i. More urban students gave a correct ratio of feet to meters than rural students--especially in the case of the longer interval.

j. More of the students gave too narrow a ratio (too few feet in a meter) than too wide a ratio.

k. More than one-third of the high school students gave estimates containing a reasonable ratio; whereas only about one-tenth of the elementary pupils did so.

l. Urban high school boys generally gave the correct ratio of feet to meters most often. Rural elementary girls and urban elementary boys least often.

Results--Height Estimates

The percentage of the children in each age, sex and home category providing a reasonable estimate for the two height intervals is provided in Table II. The percentage providing a reasonable feet to meter ratio in their estimates is also provided in Table II. As indicated earlier, a student might provide an accurate feet to meter ratio, but estimate the interval or quantity very inaccurately.

These general conclusions resulted from the analysis of the height estimates

a. About 2/5 of the children gave a reasonable height estimate in feet; fewer than 1/6 of them gave a reasonable estimate in meters. There seemed to be little difference in the accuracy of the estimates between the "short" and "long" heights.

b. A greater percent of the boys estimated the heights accurately than girls (using feet as the unit). No sex difference was observed using meters. More girls estimated low than boys; and more boys estimated high than girls.

c. More high school students gave accurate estimates than elementary pupils (45 percent or more as compared to 25 percent). Only a few of the elementary pupils gave reasonable estimates in meters. About 1/5 of the high school students gave reasonable estimates in meters.

d. About one-fourth of the pupils gave a correct Feet to Meter ratio in their estimates. Urban pupils gave a correct ratio more frequently rural pupils. Nearly two-thirds of the pupils gave too narrow a ratio or none at all.

e. Girls tended to indicate too few feet in a meter; boys tended to indicate too many.

f. Rural pupils tended to provide more accurate estimates of heights than urban pupils (using both feet and meters).

TABLE II

PERCENTAGE OF PUPILS ESTIMATING HEIGHT INTERVALS "CORRECTLY"

Group or Category	No. in Group	Greater Height			Smaller Height		
		Feet	Meters	Ratio Feet-Meters	Feet	Meters	Ratio Feet-Meters
1. ALL	2306	44	20	28	41	17	19
2. Elementary	780	25	10	10	25	13	9
3. High School	1429	49	24	36	50	17	37
4. Rural	948	45	21	25	44	19	23
5. Urban	1358	36	19	30	40	16	31
6. Boys	1245	42	21	30	43	16	30
7. Girls	1051	37	18	25	39	19	26
8. Rural Boys	473	46	21	28	47	20	26
9. Rural Girls	475	44	20	22	40	18	20
10. Urban boys	782	40	21	32	40	13	32
11. Urban Girls	576	30	16	27	39	20	29
12. High School Boys	879	46	24	38	49	17	37
13. Elementary Boys	366	31	12	10	28	12	11
14. High School Girls	550	44	23	33	51	18	36
15. Elementary Girls	414	19	9	9	22	14	7
16. Rural High School	507	60	27	35	57	22	33
17. Rural Elementary	419	26	12	11	27	13	10
18. Urban High School	922	40	21	36	46	15	38
19. Urban Elem. Boys	361	24	8	9	22	13	7
20. Rural High Sch. Boys	258	59	27	41	61	25	36
21. Urban HS Boys	621	41	23	38	43	13	37
22. Rural Elem. Boys	211	30	13	12	29	12	13
23. Urban Elem Boys.	155	33	11	7	27	12	8
24. Rural HS Girls	249	61	28	32	52	20	29
25. Urban HS Girls	301	30	19	34	50	17	41
26. Rural Elem. Girls	208	22	11	9	25	14	7
27. Urban Elem. Girls	206	17	7	10	19	14	6

Results-Weight Estimates

The percentage of the children in each age, sex and home category providing a reasonable estimate for the two "weights" is provided in Table III.

These general conclusions resulted from the analysis of the estimates:

a. About one-fourth of the children gave reasonable estimates of the weight of the objects using pounds as the unit. About one-tenth of them gave reasonable estimates using kilograms.

b. About the same percent of the boys gave reasonable estimates in pounds as girls; however, girls tended to overestimate more frequently than boys. Boys tended to underestimate the weight of the objects more frequently than girls.

c. There was no sex difference with respedt to the estimates in kilograms.

c. About one-fifth of the children gave estimates containing reasonable pounds to kilogram ratios. About two-thirds of the students gave estimates with too narrow a ratio (too few pounds in a kilogram) and about one-sixth of them gave excessively wide ratios.

e. Rural pupils tended to overestimate the weight of the objects in pounds more frequently than did the urban pupils. No other differences appeared to be significant in regard to place of residence.

f. High school students estimated the weight of the objects more accurately in both pounds and kilograms than did the elementary pupils. The elementary pupils tended to estimate high more frequently than did the high school students.

g. More high school students gave reasonable pounds in a kilogram ratios in their estimates than did elementary students (about one-fourth as compared to one-tenth).

Results-Temperature Estimates

Most of the estimates of temperature were made in the late fall. The actual temperature at which the estimates were made ranged from about 0^{o} C. to 20^{o} C.

The percentage of the children in each age, sex and home category providing a reasonable estimate of the temperature is provided in Table IV.

In this activity, any estimate of temperature using the Fahrenheit scale more than five degrees above or below the actual temperature was considered to be inaccurate. Any estima of temperature using the Centigrade scale more than three degrees above or below the actual temperature was considered to be inaccurate.

These general conclusions resulted from the analysis of the temperatu estimates:

a. About three-tenths of the pupkl gave accurate estimates of the temperature using Fahrenheit degre About one-sixth of them gave reasonably accurate estimates in Centigrade.

b. Only a few of the students gave estimates containing reasonable Fahrenheit to Centigrade relationships.

c. No sex difference were evident in the temperature estimates.

d. A greater percentage of the urban pupils gave reasonable estimates of temperature than rural pupils using both scales. Nearly twice as great a percentage of the urban pupils gave correct estimate of centigrade temperature as rural pupils (21.1 percent as compared to 11.4 percent). However, about half the pupils gave no estimate i centigrade degrees.

TABLE III

PERCENTAGE OF PUPILS ESTIMATING WEIGHTS "CORRECTLY"

Group or Cagegory	No.in Group	Lighter Weight Pounds-	Kilo- grams	Reas.Ratio Pds.-Kilo.	Heavier Weight Pounds	Kilo- grams	Reas.Ratio Pds.-Kilo.
1. ALL	2306	25	12	22	27	12	20
2. Elementary	780	21	9	13	23	12	11
3. High School	1429	29	13	27	29	13	25
4. Rural	948	24	12	23	28	14	19
5. Urban	1358	28	12	21	27	12	21
6. Boys	1255	26	12	21	28	12	19
7. Girls	1051	26	13	23	26	13	21
8. Rural Boys	473	25	12	24	28	14	20
9. Rural Girls	475	23	11	23	27	14	18
10. Urban Boys	782	27	12	20	27	11	18
11. Urban Girls	576	28	13	23	26	13	24
12. High School Boys	879	28	13	25	29	12	23
13. Elementary Boys	366	22	10	13	24	12	10
14. High School Girls	550	29	13	30	28	14	29
15. Elementary Girls	414	20	8	13	23	11	11
16. Rural High School	507	26	11	28	34	11	24
17. Rural Elementary	419	21	12	18	19	17	13
18. Urban High School	922	30	14	27	25	14	26
19. Urban Elementary	361	21	5	31	28	5	8
20. Rural High School	258	27	11	30	34	12	28
21. Urban High School	621	29	14	23	27	12	21
22. Rural Elementary Boy	211	21	13	18	21	16	12
23. Urban Elementary Boy	185	23	5	7	28	6	8
24. Rural HS Girls	249	25	11	26	34	10	21
25. Urban HS Girls	301	33	14	34	23	17	36
26. Rural Elementary Girls	208	21	11	19	17	19	15
27. Urban Elementary Girls	206	19	5	7	29	4	8

TABLE IV

PERCENTAGE OF PUPILS ESTIMATING TEMPERATURE "CORRECTLY"

Group or Category	No. in Group	Percent Est. Fah. Correctly	Percent Est. Cent. Correctly	Percent Giving Same C. & F.	Percent Giving Larger C. than F.	Percent Giving Smaller C. than F.
1. ALL	2306	44	21	7	18	75
2. Elementary	780	38	18	11	23	66
3. High School	1429	50	21	5	14	79
4. Rural	948	43	15	6	19	76
5. Urban	1358	49	25	8	18	74
6. Boys	1255	46	20	7	17	76
7. Girls	1051	47	19	7	19	73
8. Rural Boys	473	41	14	4	20	76
9. Rural Girls	475	44	16	7	17	76
10. Urban Boys	782	48	24	8	15	77
11. Urban Girls	576	50	27	8	21	71
12. High School Boys	879	50	24	6	14	80
13. Elementary Boys	366	36	12	9	23	67
14. High School Girls	550	52	17	4	14	78
15. Elementary Girls	414	39	22	13	22	65
16. Rural High School	507	48	22	4	16	80
17. Rural Elementary	419	36	4	8	22	70
18. Urban High School	922	52	20	6	15	79
19. Urban Elementary	361	40	33	14	24	61
20. Rural High School	258	47	21	3	16	81
21. Urban High School	621	51	25	7	13	80
22. Rural Elementary Boys	211	35	6	6	25	69
23. Urban Elementary Boys	155	38	21	13	22	65
24. Rural HS Girls	249	49	22	4	16	80
25. Urban HS Girls	301	54	12	4	19	76
26. Rural Elem. Girls	208	38	2	10	19	71
27. Urban Elem. Girls	206	41	42	16	26	59

e. A greater percentage of the high school students gave accurate estimates in both Fahrenheit and centigrade degrees than the elementary pupils.

f. More elementary pupils gave no centigrade estimates than high school students.

Results-Acreage Estimates

The percentage of the children in each age, sex and home category providing a reasonable estimate for the acreage of the plot selected by their teacher is contained in Table V. Each teacher was asked to select an area of about one-fourth an acre and ask her pupils to estimate its size, thereby providing some idea of children's percepts of the acre.

These general conclusions resulted from the analysis of the acreage estimates.

a. About one-fifth of the acreage estimates were reasonably correct (18 percent of them were within 25 percent of the actual area).

b. About one-tenth of the pupils said the area contained fewer acres than it really contained. Nearly seven-tenths thought the area contained more acres than actually.

b. No sex differences were noted with respect to the acreage estimates.

c. More urban pupils gave accurate estimates than rural pupils (19.7 percent as compared to 15.8 percent). More rural pupils underestimated than did urban pupils.

f. Nearly twice as great a percentage of high school pupils gave accurate estimates than did elementary pupils.

Summary and Discussion

The writers were surprised and pleased at the willingness of the teachers they contacted to participate with their pupils in this study. A large number of them wrote that they subsequently used this as an outdoor activity in an attempt to help their students to develop percepts of distance, height, etc. and to provide them with experience using metric unit

Support was found for hypothesis "a" of this study -- School children (grades 4-12) have inaccurate or invalid percepts of intervals and quantities of distance, weight, height, area and temperature. (Estimates smaller than 75% or larger than 125% of the actual interval or quantity being considered inaccurate. A return of more than 50% inaccurate estimates aribtrarily being considered as being supportive of this hypothesis

Only in a very few instances did as many as half of the children provide reasonably accurate estimates. Far more frequently, three-fourths or more of them gave inaccurate estimates

Support was found for hypothesis "b" -- School children's percepts expressed in English units are more accurate than those expressed in metric units.

The small percentage of the estimates, in each case, containing a reasonably ratio between the metric unit and the English unit being used surprised the writers. They had suspected that the students would have considerable knowledge of the conversion ratios and would apply these when making their estimates. Apparently few did so.

Little support was found for the other hypotheses. It appears as if children do estimate some things, such as distance, more accurately than other things, such as weight. Furthermore, some differences were noted by sex and by home situation. High school students did much better than the younger children in most cases.

TABLE V

PERCENTAGE OF PUPILS ESTIMATING ACREAGE "CORRECTLY"

Group or Category	No. in Group	Percent giving Reasonable Estimate
1. ALL	2306	18
2. Elementary	780	12
3. High School	1429	22
4. Rural	948	16
5. Urban	1361	20
6. Boys	948	16
7. Girls	1051	20
8. Rural Boys	473	14
9. Rural Girls	475	17
10. Urban Boys	782	18
11. Urban Girls	576	22
12. High School Boys	879	19
13. Elementary Boys	366	11
14. High School Girls	550	26
15. Elementary Girls	414	13
16. Rural High School	507	20
17. Rural Elementary	419	10
18. Urban High School	922	23
19. Urban Elementary	361	11
20. Rural High School Boys	258	19
21. Urban High School Boys	621	20
22. Rural Elementary Boys	211	9
23. Urban Elementary Boys	155	13
24. Rural High School Girls	249	19
25. Urban High School Girls	301	32
26. Rural Elementary Girls	208	15
27. Urban Elementary Girls	206	10

Viewpoint

We believe it is essential in communicative situations for teachers and students to have comparable percepts. One is forced to question the kinds of outcome relative to the teaching-learning process in which those intervals and quantities are involved and in which there is no commonality of understanding. How can teachers be expected to communicate with pupils and be effective in the teaching-learning process if their own and their pupils percepts are inaccurate, unclear, and invalid?

The lack of understanding by students at all levels, elementary, secondary, college, of metric units is particularly distressing--especially at this time in which we rapidly move toward the general adoption of this system of measure throughout our entire system and discard the English units. For decades science teachers as well as others have been hammering away at metric units,apparently with little success.

Considerable evidence exists which supports the notion that percepts can be clarified and reinforced through direct, first-hand experience.25 Thus, it seems not only highly desirable but essential that students at all levels of the educational ladder should have direct experiences both inside and outside the classroom to clarify and reinforce these interval and quantity percepts which they will use in and out of school, and throughout their lifetime.

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